Facial Feedback Mechanisms and Emotional Processing: A Clinical Study on Perception of Social and Biological Motion Stimuli

Dr. Ahmed Benali[1]*, Dr. Salma Idrissi[1], Dr. Youssef El Amrani[2]
[1]Department of Clinical Psychology, Ibn Sina University Hospital, Rabat, Morocco
[2]Department of Neurobehavioral Sciences, Mohammed V Military Hospital, Rabat, Morocco

Abstract

In this research, we replicated the effect of muscle engagement on perception such that the recognition of another's facial expressions was biased by the observer's facial muscular activity (Blaesi & Wilson, 2010). We extended this replication to show that such a modulatory effect is also observed for the recognition of dynamic bodily expressions. Via a multi-lab and within-subjects approach, we investigated the emotion recognition of point-light biological walkers, along with that of morphed face stimuli, while subjects were or were not holding a pen in their teeth. Under the 'pen-in-the-teeth' condition, participants tended to lower their threshold of perception of 'happy' expressions in facial stimuli compared to the 'no-pen' condition; thus replicating the experiment by Blaesi and Wilson (2010). A similar effect was found for the biological motion stimuli such that participants lowered their threshold to perceive 'happy' walkers in the 'pen-in-the-teeth' compared to the 'no-pen' condition. This pattern of results was also found in a second experiment in which the 'no-pen' condition was replaced by a situation in which participants held a pen in their lips ('pen-in-lips' condition). These results suggested that facial muscular activity not only alters the recognition of facial expressions but also bodily expression.

Keywords: face; emotions; biological motion; mirror neurons; embodied cognition.

Introduction

The two-way relationship between action and perception has demonstrated that perception affects motor actions (e.g. Salgado-Montejo et al., 2016) and that motor actions affect perception (e.g., Bach-Y-Rita et al., 1969; Gonzalo-Fonrodona & Porras, 2013; Yonemitsu et al., 2017). Thus, a crossmodal correspondence seems to exist between perception and action. This is a central tenet of embodied cognition.

It took a century for William James's theory of emotions (1890) to be supported by evidence from neuroscience regarding the bodily feedback hypothesis. The James-Lange theory of emotion suggested that emotions could either be suppressed or intensified by the body's cardiovascular, visceral of muscular feedback. In 2003 researchers tested that claim. Asking subjects to imitate facial expressions triggered neural activation in limbic regions such as the amygdala (Carr et al. 2003). In a related experiment, Hennenlotter and colleagues (2009) tested their cosmetic treatment patients either two weeks prior to or after their scheduled injection of botulinum toxin to frown muscles, thus blocking those muscles' ability to contract. The procedure involved asking patients to imitate angry facial expressions. The results showed a clear pattern: blockage of the frown muscles reduced the activation of the left amygdala during the imitation.

Blaesi and Wilson (2010) provided evidence in favour of the effect of motor actions on perception by covertly manipulating facial expressions and measuring the impact on the perception of emotional faces. Their Experiment 1 showed that when participants were covertly set to smile, their threshold to recognise a face as portraying happiness was lowered. Researchers induced a covert smile by having participants hold a pen in their teeth (see Figure 1). The covert facial expression set by this act has been shown to benefit the processing of emotionally-matching valenced stimuli (e.g. Buck, 1980; Davis et al., 2017; Niedenthal, 2007; Strack, Martin, & Stepper, 1988; see also Marmolejo-Ramos & Dunn, 2013). Studies of the effects of facial manipulation by means other than the 'pen-in-the-teeth' have shown that doing so influences the processing of emotional stimuli (e.g. Rhodewalt & Comer, 1979; Wood et al., 2016a, 2016b; Havas et al., 2010; Parzuchowski & Szymków-Sudziarska, 2008).

Emotional information can also be extracted from sources other than the face. In communicative contexts, people use language buttressed with para-linguistic (e.g. pitch and prosody) and kinesics cues (e.g. body postures and gestures; see Cevasco & Marmolejo-Ramos, 2013; Holler & Levinson, 2019; Parzuchowski & Wojciszke, 2014). Each cue is a source of emotional information (e.g. see Adolphs, 2002 for evidence as to how emotional information can be extracted from prosody). Research in biological motion (Johansson, 1973) has shown that emotional information can indeed be extracted from kinesics (e.g. Clarke et al., 2005; Ikeda & Watanabe, 2009). Recent evidence has further shown that covertly adopting a negatively-laden walking style (i.e. the walking style of a depressed person) leads to recalling more negative than positive words. The recall pattern reversed when participants adopted a positively-laden walking style (i.e. the style of a happy person; Michalak et al., 2015). In a nutshell, perceptual and motor systems are particularly intertwined during the processing of emotionally-valenced stimuli (see Holstege, 1992 for the coupling between emotions and motor systems and Satpute et al., 2015 for a meta-analysis of evidence favouring a coupling between emotions and sensory and perceptual systems).

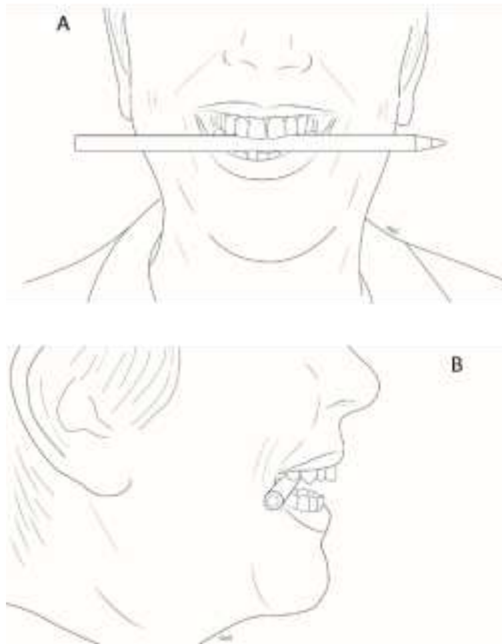


Figure 1. Illustration of the way a pen is held between the teeth in order to induce a covert smile. Figure A shows a frontal view and Figure B a profile view.

Neuroscientific evidence further suggests that facial expressions, e.g. an involuntary smile, not only comprise premotor and face motor areas but also the brain areas involved in social cognition (Schilbach et al., 2008). The activation of premotor areas has been linked, in turn, with the activation of mirror neurons (see Molenberghs et al., 2009). These are multimodal association neurons that match action perception and action execution (see Gallese, 2009; Keysers, 2009; Wilson & Knoblich, 2005) and are indeed needed in social cognitive processes (see Spaulding, 2013). Given the participation of emotions in social processes, it follows that emotion processing consists of integrating multimodal perceptual and motor components such that one component can activate another co-occurring component in order to predict and comprehend emotional states (see Wood et al., 2016b). A likely multimodal brain area for the integration of perceptual and motor information related to emotional stimuli is the superior temporal sulcus (STS). The STS participates in the processing of biological motion (Grossman et al., 2005) and facial expressions (Tseng et al., 2015).

Thus, it can be entertained that the engagement of a specific motor system related to a specific emotion could affect the perception of emotionally-valenced stimuli that mirror the specific, engaged motor system as well as other motor systems that resonate with that emotion. Specifically, eliciting a covert smile could cause the online processing of stimuli (e.g. ambiguous faces or body movements) to be perceived in a more positive manner. Much of the embodiment literature focuses on off-line effects, i.e. how the bodily cues can change the recall of stored representations (Niedenthal et al., 2005). The design of our experiments allows the tracing of on-line processing. That is, we seek to track the ongoing change of perception of the presented stimuli. Therefore, the goal of this experiment is to show the effects of action on perception by replicating the findings of Blaesi and Wilson (2010) and to extend their results to the case of biological motion stimuli.

Relatedly, a recent multi-lab replication of the facial feedback hypothesis (Wagenmakers et al., 2016) did not replicate the phenomenon that covertly manipulating facial action affects the perceived funniness of cartoons (Strack et al., 1988). However, the experimental social psychology community has debated whether duplicating this well-known experiment was the best test to replicate the theory that underpins the facial feedback hypothesis (Strack, 2016, 2017). Indeed, a new meta-analysis (Coles, Larsen & Lench, 2019) of 286 effect sizes (from 138 studies) found weak support for the claim that facial feedback does influence emotional experience. We believe that the experiments reported below test the facial feedback theory directly, as the stimuli we used were more relevant for guiding the participants' behaviour and more engaging to assess their valence. After all, judgements of cartoon funniness are less relevant for future behaviour than assessing the valence of an ambivalent face or a silhouette of a person walking towards you.

Methods

Experiment 1

Participants

Volunteers were university students in the Tokyo area (close to Waseda University), psychology undergraduate student at SWPS University of Social Sciences and Humanities (Sopot), and Stockholm University (Stockholm), (see Table 1). The ethics committee boards from each university approved the experiment. Participants gave written, informed consent to abide by the principles of the Declaration of Helsinki (WMA, 2013).

Laboratory	Gender (Mdn $_{age}$ ± MAD) [range $_{age}$]		*Total*	Age	
	Males	Females		Range	Mdn ± MAD
Japan	22 (20.5 ± 1.23) [18-23]	18 (20 ± 1.72) [18-28]	*40*	18-28	20 ± 1.45
Poland	19 (23 ± 2.11) [19-36]	21 (21 ± 2.57) [19-33]	*40*	19-36	23± 2.55
Sweden	14 (26 ± 2.07) [21-31]	26 (26 ± 2.81) [19-37]	*40*	19-37	26 ± 2.55
Total			***120***		
Total (gender)	*Males = 55*	*Females = 65*			
Total age range				*18-37*	
Total Mdn $_{age}$ ***± MAD***					*22±3.08*

Table 1. Demographics of the participants in the experiment. Mdn = median; MAD = median absolute deviation.

Materials

In the facial expression evaluation task, the stimuli by Blaesi and Wilson (2010) were used. They consisted of 11 pictures of the same face morphed on a continuum ranging from frowning to smiling. In the bodily expression evaluation task, 11 video clips of point-light biological walkers, ranging on a continuum from sad walking to happy walking, were presented. These video clips were made by using the BML publisher software (Troje, 2002, 2008). The experiment was implemented in PsychoPy (Peirce, 2007). The participants' facial, muscular activity was manipulated by requesting that they hold a pen horizontally with their teeth.[1]

Procedure

Upon arrival at the laboratory, each participant was ushered into a room and seated in front of a computer. The 'pen-in-the-teeth' and 'no-pen' conditions were compared in a within-subjects fashion. In the 'pen-in-the-teeth' condition, participants were instructed to hold a pen horizontally with their teeth, without touching the pen with their lips (see Figure 1). In the 'no-pen' condition, participants did not hold a pen in their mouth.

Participants were told that the aim of the experiment was to test their ability to multitask rather than to test the effect of making a smile. The experiment consisted of two large blocks: facial expression stimuli (shown for 750 ms each) were presented in one block, and biological motion videos (shown for 950 ms each) were presented in the other. Within each block there were 7 sub-blocks of 22 randomly-shown stimuli; i.e., each stimulus was presented twice, and the instructions on the screen asked participants to alternate between the 'pen-in-the-teeth' and 'no-pen' conditions for each trial. Thus, each participant underwent 308 trials ($22_{\text{stimuli}} \times 7_{\text{sub-blocks}} \times 2_{\text{large blocks}}$; 154 trials in the facial expression and 154 trails in the biological motion tasks). The responses 'sad' and 'happy' were mapped onto the leftward (←) and rightward (→) arrow navigation keys; the upward navigation key (↑) was used to call up the trials. The order of the large

[1]Disposable wooden chopsticks were used by the Japanese and Polish participants and disposable wooden pencils were used by the Swedish participants. These items were considered more convenient and hygienic substitutes for the traditional ballpoint pen. Also, wooden chopsticks and pencils have smooth, porous surfaces that prevent them slipping from the mouth. However, we refer to these items as 'pens' to follow jargon within the field.

blocks and the key allocation were counterbalanced; thus, participants were randomly allocated to four, counterbalanced conditions.

The timeline of each trial is presented in Figure 2. Each trial started with a screenshot instructing participants to hold or not hold the pen (‘pen’ for the ‘pen-in-the teeth’ condition and ‘free’ for the ‘no-pen’ condition). After this instruction, a fixation cross (+) was presented for 1000ms. Immediately after, and depending on the experimental block, the emotional expression stimulus or the bodily expression stimulus was presented. Participants were asked to evaluate as quickly and accurately as possible the emotion of each stimulus as ‘sad’ or ‘happy’. The next trial started after a 2000ms inter-trial interval.

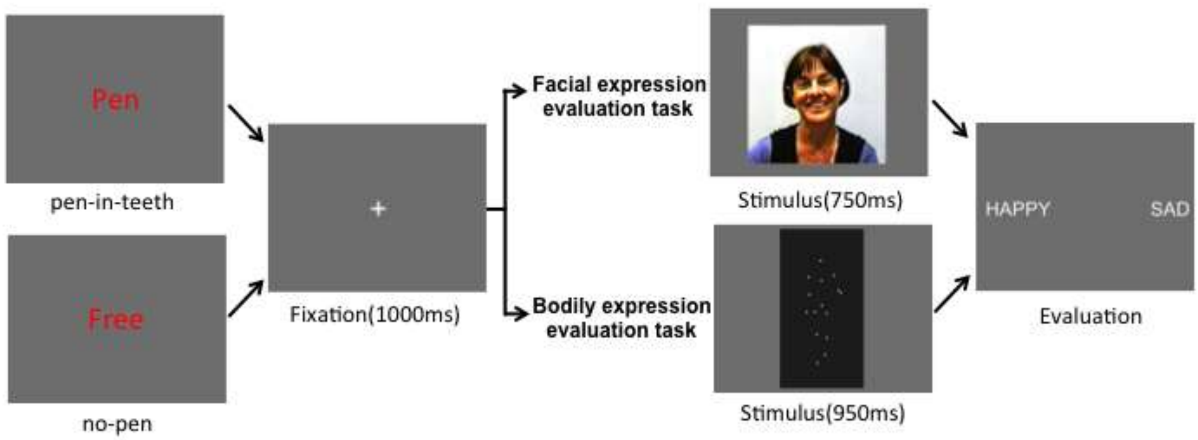


Figure 2. Illustration of the experimental sequence in each task.

Design and statistical analyses

We estimated each participant's point of subjective equality (PSE) for perceiving the expression as 'happy' in each of the two conditions ('pen-in-the-teeth' vs. 'no-pen') in each task. The PSE estimates were obtained by using a psychometric function in a similar vein as the experiment by Blaesi and Wilson (2010). This function was attained by a Logit model analysis (models were fitted by using binomial distribution and logit link function in R) with stimulus number 0 ('fully sad') to 10 ('fully happy') as the independent variable. The estimated PSEs were defined as 50% 'happy' responses and were used as the dependent variable in the analyses. The estimated PSEs originated from participants who wrongly mapped the response keys and PSEs with values outside the 0 to 10 range were excluded from the analyses. To verify whether a distinct pattern of responses occurred for each condition, and whether these occurrences were influenced by gender and/or laboratory, we conducted a $2_{ws} \times 2_{bs} \times 3_{bs}$ (ws = within-subjects; bs = between-subjects; Condition × Gender × Laboratory) mixed ANOVA on the PSEs of each task (R codes, stimuli, and data sets for the current and supplementary analyses can be found at: https://figshare.com/projects/emotional_faces_and_biological_motion_study/71441).

Results

Data from four Swedish participants were excluded from our analysis because their response functions were opposite to what would be expected had they understood the mapping between their recognition and key responses (i.e. either they did not follow the instructions correctly, or they wrongly mapped the response keys).

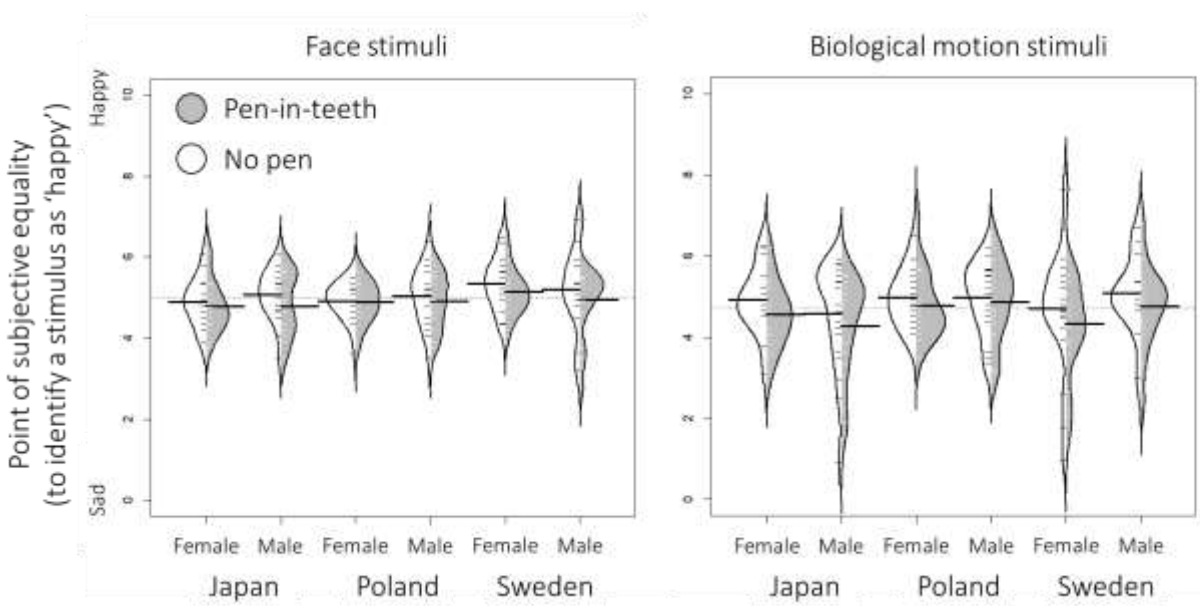
Figure 3 shows the distribution of each participant's PSE estimates as a function of gender and laboratory in the facial expression evaluation and in the bodily expression evaluation tasks. The ANOVA indicated that only the factor 'condition' was significant in both tasks (facial expression task: $F(1, 110)=19.63$, $p=2.22e^{-5}$, $\eta^2=0.016$; bodily expression task: $F(1, 109)=19.29$, $p=2.6e^{-5}$, $\eta^2=0.017$) [2]. That is, participants' threshold to label a face as 'happy' lowered when they

---

[2] These ANOVAs were carried out using the 'aov' function in R with the following formula: aov(PSE ~ laboratory * gender * condition + Error(participant.ID) , data = xx); where 'xx' stands for the facial expression or the biological motion dataset. The effect sizes were obtained via the function 'anova_stats' in the 'sjstats' R package. Note the same

were in the 'pen-in-teeth' condition (facial expression task: $M_{pen\text{-}in\text{-}teeth}$=4.91 ± 0.69, $M_{no\text{-}pen}$=5.08 ± 0.66; bodily expression task: $M_{pen\text{-}in\text{-}teeth}$=4.58 ± 1.09, $M_{no\text{-}pen}$=4.86 ± 1.05). In other words, when participants were holding a pen in their teeth, they tended to label the observed stimuli as 'happy' more frequently than when no pen was held.

While the current results refer to effects that are specific to an emotional expression, namely, happiness, it could be argued that the experimental manipulations do not allow to determine whether the effect was caused by the induction of a specific (smiling) face or by a more general effect related to the contraction versus relaxation of facial muscles. Hence, we conducted a second experiment in which the 'no-pen' condition was substituted by a condition in which participants held a pen in their lips, 'pen-in-lips' condition.



results are obtained by using a linear mixed model as there is only one PSE per participant per condition (i.e. lmer(PSE ~ laboratory * gender * condition + (1 | participant.ID) , data = xx); via the 'lmerTest' R package).

Figure 3. Distribution of PSE thresholds as functions of gender and laboratory in the facial and bodily expression evaluation tasks. The solid horizontal lines represent mean values. The grey dotted line represents the grand mean.

Experiment 2

Participants

Volunteers were university students at Kyushu University (Japan), SWPS University of Social Sciences and Humanities (Poland), and Universidad Complutense de Madrid (Spain) [3], (see Table 2). The ethics committee boards from each university approved the experiment. Participants gave written, informed consent to abide by the principles of the Declaration of Helsinki (WMA, 2013).

Laboratory	**Gender (Mdn $_{age}$ ± MAD) [range $_{age}$]**		***Total***	**Age**	
	Males	**Females**		**Range**	**Mdn ± MAD**
Japan	22 (19 ± 1.48) [18-23]	24 (19 ± 1.48) [18-23]	*46*	18-23	19 ± 1.48
Poland	3 (24 ± 7.41) [19-50]	42 (24.5 ± 8.15) [18-50]	*45*	18-50	24± 7.41
Spain	8 (28 ± 8.89) [18-36]	37 (20 ± 2.96) [18-33]	*45*	18-36	21 ± 4.44
Total			***136***		

[3] We strived for sampling new participants from the same countries listed in experiment 1 but it was not possible to secure participants from Sweden; hence we sampled from another language/culture (i.e. Spain).

Total (gender) *Males = 33*	*Females = 103*		
Total age range		*18-50*	
Total Mdn $_{age}$ ***± MAD***			*20.5±3.70*

Table 2. Demographics of the participants in the experiment 2. Mdn = median; MAD = median absolute deviation.

Materials

Same materials as those in Experiment 1

Procedure

Same procedure as that in Experiment 1 with the only difference that the 'no-pen' condition was replaced by condition in which participants held a pen in their lips (i.e. 'pen-in-lips' condition, See Figure 4).

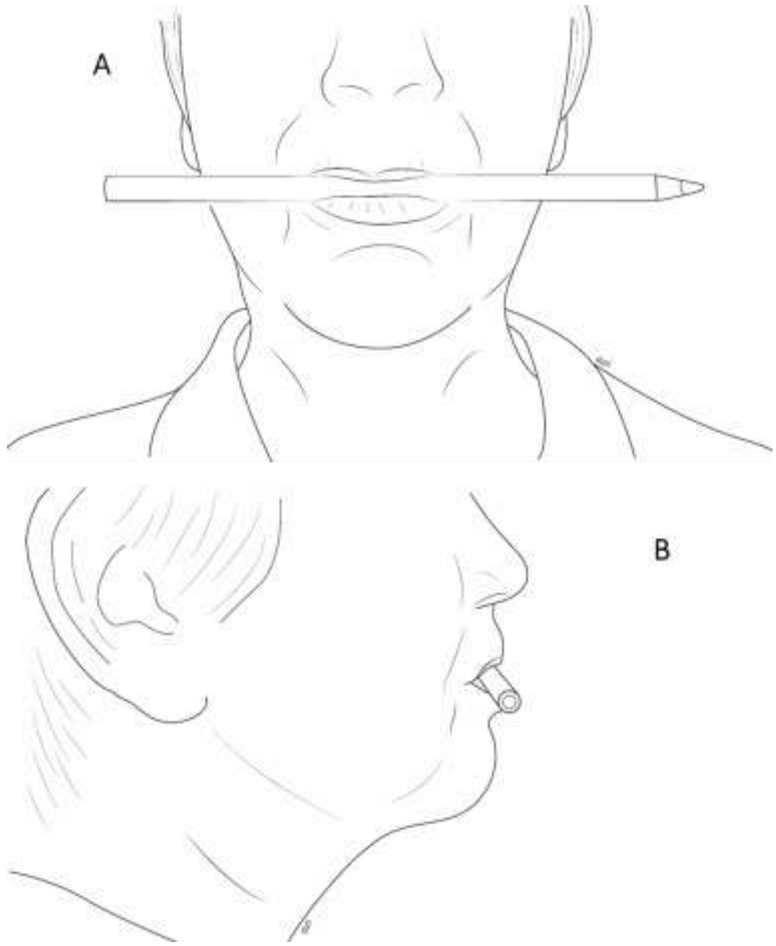


Figure 4. Illustration of the way a pen is held between the lips in order to prevent smile. Figure A shows a frontal view and Figure B a profile view.

Design and statistical analyses

Same design and statistical analyses as those reported in Experiment 1. The only difference was that PSEs were estimated for the 'pen-in-teeth' (same condition featured in experiment 1) and 'pen-in-lips' (in lieu of the 'no-pen' condition) conditions.

Results

A $2_{ws} \times 2_{bs} \times 3_{bs}$ (ws = within-subjects; bs = between-subjects; Condition × Gender × Laboratory) mixed ANOVAs on the PSEs of the 'pen-in-lips' and 'pen-in-teeth' conditions showed that only the factor 'condition' was significant (facial expression task: $F(1, 126) = 14.40$, p=2.28e^{-4} , η^2 = 0.013; bodily expression task: $F(1, 122) = 14.92$, p=1.81e^{-4} , η^2 = 0.017). That is, as in the previous experiment, participants' threshold to label a face as 'happy' lowered when they were in the 'pen-in-teeth' condition (facial expression task: $M_{pen\text{-}in\text{-}teeth}$=4.91 ± 0.73, $M_{pen\text{-}in\text{-}lips}$=5.08 ± 0.75; bodily expression task: $M_{pen\text{-}in\text{-}teeth}$=4.65 ± 1.30, $M_{pen\text{-}in\text{-}lips}$=4.99 ± 1.29). In other words, when participants were holding a pen in their teeth, they tended to label the observed stimuli as 'happy' more frequently than when holding a pen in their lips (see Figure 5).

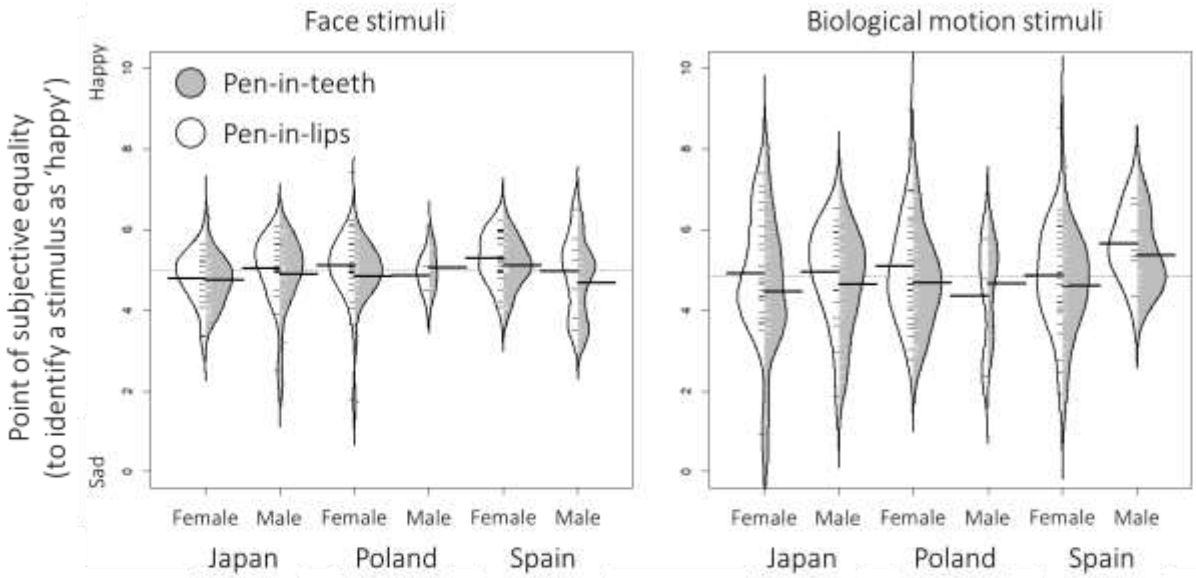


Figure 5. Distribution of PSE thresholds as functions of gender and laboratory in the facial and bodily expression evaluation tasks. The solid horizontal lines represent mean values. The grey dotted line represents the grand mean.

Discussion

The first multi-laboratory experiment replicated the findings that a covert smile lowers the threshold to recognise faces as 'happy' while not sustaining a smile does not lead to such an effect. The experiment further showed that a covert smile lowers the threshold to recognise a biological walking motion as more positive than when no smile is sustained. Furthermore, a second multi-laboratory experiment corroborated these findings when the 'no-pen' condition was replaced by a condition in which participants were prevented from smiling; 'pen-in-lips' condition. These results provide further evidence in favour of the bidirectional link between perception and action.

We used the dynamic, biological motions as the stimuli of bodily expressions, whereas the stimuli of facial expressions were still photographs. In the context of facial mimicry research, it has been shown that dynamic facial expressions elicit greater facial mimicry compared to static presentations of faces (Sato & Yoshikawa, 2007). In an experiment of biological motion, Atkinson et al. (2007) noted the importance of kinematic movement for emotional recognition of bodily expression by showing that emotion classification accuracy was impaired when the movie clips of bodily expression were inverted or played backwards. Further, an experiment using functional magnetic resonance imaging has indicated that some neural circuits are specifically activated when watching dynamic bodily movements which express angry states (e.g., hypothalamus, the ventromedial prefrontal cortex, the temporal pole and the premotor cortex; Pichon, de Gelder & Grezes, 2008). Future studies could investigate differences between recognition of emotion from dynamic and static stimuli in order to assess the modulation effect observed in the present experiment. Indeed, a more robust examination of the role of facial mimicry in emotion understanding would require testing hypotheses with individuals with Moebius syndrome.

Individuals with this syndrome suffer from facial paralysis that prevents them from forming facial expressions (De Stefani, Nicolini, Belluardo, & Ferrari, 2019)

A recent large-scale, multi-laboratory replication experiment showed that a covert smile has no effect on the processing of emotionally-valenced stimuli. Specifically, Wagenmakers et al. (2016) found that a covert smile elicited by holding a pen-in-the-teeth did not change the ratings of cartoons as being funnier when a covert frown was elicited by holding a pen in the lips. This result thus did not replicate the original experiment of Strack, Martin and Stepper (1988). Although that replication experiment and ours seem to follow a similar logic and use similar manipulations, they do differ. For example, unlike our first experiment, the procedure in the 1988's experiment required holding a pen between the lips (for the control condition that prevents a smile) or between the teeth (to induce a smile). We addressed this issue, though, in a second experiment. Importantly, there was a large discrepancy between Wagenmakers et al.'s study and our studies as to the dependent variable (and hence the underlying process). In the 1988 procedure, as well as in the replication attempt by Wagenmakers et al. (2016), the stimuli were supposedly already mildly positive. Thus, what was hypothesised was that the facial feedback from the unobtrusive smile 'create[d] a shift' in funniness ratings that corresponded with the positivity bias. In our procedure, however, we showed the effectiveness of the manipulation in disambiguating ambivalent stimuli. That is, the bodily cues of unobtrusive smiles were only taken into account when deciding whether an emotionally ambivalent stimulus was positive or not.

Furthermore, Strack (2016) argued that the replicators tested the funniness of 1980s' cartoons that most likely were not understood in the same way 30 years later. However, Wagenmakers et al (2016) used different comic strips and ensured they were equally and moderately as funny as the original strips. Our results add evidence to this debate: the stimuli do not need to be positive in the first place. On the contrary, we argue that the sensorimotor interference should be observed especially for those stimuli which are ambiguous. As this kind of interference might influence early stages of perceptual processing (Price, Dieckman & Harmon-Jones, 2012), it should give an additional clue on the valance of the perceived stimuli and should disambiguate the neutral from the mildly amusing stimuli. In our facial expression categorization task (original files from McCullough & Emmorey, 2009), the presented face was neither smiling nor sad but was digitally transformed into an ambivalent morph. This is where we observed the strongest PSEs shift due to the facial feedback.

Conclusion

The current experiments suggest that facial motor activation seems to compromise motor systems that are not confined to the face and do engage other body parts that resonate with the implied emotional state. That is, the emotion implied by the covert facial expression seems to engage a wide range of motor systems that, all together, are representative of the ongoing emotional state.

References

Adolphs, R. (2002). Neural systems for recognizing emotion. *Current Opinion in Neurobiology, 12*(2), 169-177.

Atkinson, A. P., Tunstall, M. L., & Dittrich, W. H. (2007). Evidence for distinct contributions of form and motion information to the recognition of emotions from body gestures. *Cognition, 104(1)*, 59-72.

Bach-Y-Rita, P., Collins, C. C., Saunders, F. A., White, B., & Scadden, L. (1969). Vision substitution by tactile image projection. *Nature, 221,* 963-964.

Blaesi, S., & Wilson, M. (2010). The mirror reflects both ways: action influences the perception of others. *Brain and Cognition, 72,* 306-309.

Buck, R. (1980). Nonverbal behavior and the theory of emotion: The facial feedback hypothesis. *Journal of Personality and Social Psychology, 38*(5), 811–824.

Carr, L., Iacoboni, M., Dubeau, M.C., Mazziotta, J.C., & Lenzi, G.L. (2003). Neural mechanisms of empathy in humans: a relay from neural systems for imitation to limbic areas. *Proceedings of National Academy of Science, 100*, 5497-5502.

Cevasco, J., & Marmolejo-Ramos, F. (2013). The importance of studying the role of prosody in the comprehension of spontaneous spoken discourse. *Revista Latinoamericana de Psicología, 45*(1), 21-33.

Clarke, T. J., Bradshaw, M. F., Field, D. T., Hampson, S. E., & Rose, D. (2005). The perception of emotion from body movement in point-light displays of interpersonal dialogue. *Perception, 34*, 1171-1180.

Coles, N. A., Larsen, J., & Lench, H. C. (2019). A meta-analysis of the facial feedback literature: Effects of facial feedback on emotional experience are small and variable. *Psychological Bulletin, 145*(6), 610-651

Davis, J. D., Winkielman, P., & Coulson, S. (2017). Sensorimotor simulation and emotion processing: impairing facial action increases semantic retrieval demands. *Cognitive, Affective, & Behavioral Neuroscience, 17*(3), 652-664.

De Stefani, E., Nicolini, Y., Belluardo, M., & Ferrari, P. F. (2019). Congenital facial palsy and emotion processing: The case of Moebius syndrome. *Genes, Brain, and Behavior, 18* (1): e12548. doi: 10.1111/gbb.12548.

Emmorey, K., & McCullough, S. (2009). The bimodal bilingual brain: effects of sign language experience. *Brain and Language*, *109*(2–3), 124–132.

Gallese, V. (2009). Mirror neurons, embodied simulation, and the neural basis of socialidentification. *Psychoanalytic Dialogues*, *19*(5), 519-536.

Gonzalo-Fonrodona, I., & Porras, M. A. (2013). Scaling effects in crossmodal improvement of visual perception by motor system stimulus. *Neurocomputing, 114*, 76-79.

Grossman, E. D., Battelli, L., & Pascual-Leone, A. (2005). Repetitive TMS over STS disrupts perception of biological motion. *Vision Research, 45*(22), 2847-2853.

Havas, D., Glenberg, A. M., Gutowski, K. A., Lucarelli, M. J., & Davidson, R. J. (2010). Cosmetic use of botulinum toxin-A affects processing of emotional language. *Psychological Science, 21*(7), 895-900.

Hennenlotter, A., Dresel, C., Castrop, F., Ceballos-Baumann, A. O., Wohlschlager, A. M., & Haslinger, B. (2009). The Link between Facial Feedback and Neural Activity within Central Circuitries of Emotion—New Insights from Botulinum Toxin -Induced Denervation of Frown Muscles. *Cerebral Cortex, 19,* 537-542.

Holler, J., & Levison, S. C. (2019). Multimodal Language Processing in Human Communication. *Trends in Cognitive Sciences, 23* (8), 639-652.

Holstege, G. (1992). The emotional motor system. *European Journal of Morphology, 30* (1), 67-79.

Ikeda, H., & Watanabe, K. (2009). Anger and happiness are linked differently to the explicit detection of biological motion. *Perception, 38*, 1002-1011.

James, W. (1890). *The Principles of Psychology.* New York: Holt.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception & Psychophysics, 14*(2), 201-211.

Keysers, C. (2009). Mirror neurons. *Current Biology, 19* (21), R971-R973.

Marmolejo-Ramos, F., & Dunn, J. (2013). On the activation of sensorimotor systems during the processing of emotionally-laden stimuli. *Universitas Psychologica, 12*(5), 1511-1542.

Michalak, J., Rohde, K., & Troje, N. F. (2015). How we walk affects what we remember: gait modifications through biofeedback change negative affective memory bias. *Journal of Behavior Therapy and Experimental Psychiatry, 46,* 121-125.

Molenberghs, P., Cunnington, R., & Mattingley, J. (2009). Is the mirror neuron system involved in imitation? A short review and meta-analysis. *Neuroscience and Behavioral Reviews, 33,* 975-980.

Niedenthal, P. M. (2007). Embodying emotion. *Science, 316*, 1002-1005.

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review, 9*, 184-211.

Parzuchowski, M., & Szymkow-Sudziarska, A. (2008). Well, slap my thigh: Expression of surprise facilitates memory of surprising material. *Emotion, 8*(3), 430-434. doi: 10.1037/1528-3542.8.3.430.

Parzuchowski, M., Wojciszke, B. (2014). Hand over Heart Primes Moral Judgments and Behavior. *Journal of Nonverbal Behavior, 38,* 145-165. doi: 10.1007/s10919-013-0170-0.

Peirce, J. W. (2007). PsychoPy—Psychophysics software in Python. *Journal of Neuroscience Methods, 162*(1-2), 8-13.

Pichon, S., de Gelder, B., & Grezes, J. (2008). Emotional modulation of visual and motor areas by dynamic body expressions of anger. *Social Neuroscience, 3(3-4)*, 199-212.

Price, T. F., Dieckman, L. W., & Harmon-Jones, E. (2012). Embodying approach motivation: body posture influences startle eyeblink and event-related potential responses to appetitive stimuli. *Biological Psychology*, *90*(3), 211-217.

Rhodewalt, F., & Comer, R. (1979). Induced-Compliance attitude change: Once more with feeling. *Journal of Experimental Social Psychology, 15*(1), 35-47.

Salgado-Montejo, A., Marmolejo-Ramos, F., Alvarado, J. A., Arboleda, J. C., Suarez, D. R., & Spence, C. (2016). Drawing sounds: Representing tones and chords spatially. *Experimental Brain Research.* DOI: 10.1007/s00221-016-4747-9.

Sato, W., & Yoshikawa, S. (2007). Spontaneous facial mimicry in response to dynamic facial expressions. *Cognition, 104(1)*, 1-18.

Satpute, A. B., Kang, J., Bickart, K. C., Yardley, H., Wager, T. D., & Barrett, L. F. (2015). Involvement of Sensory Regions in Affective Experience: A Meta-Analysis. *Frontiers in Psychology, 6* (1860). DOI: 10.3389/fpsyg.2015.01860.

Schilbach, L., Eickhoff, S. B., Mojzisch, A., & Vogeley, K. (2008). What's in a smile? Neural correlates of facial embodiment during social interaction. *Social neuroscience*, *3*(1), 37-50.

Spaulding, S. (2013). Mirror neurons and social cognition. *Mind & Language, 28* (2), 233–257.

Strack, F. (2016). Reflection on the Smiling Registered Replication Report. *Perspectives on Psychological Science, 11*(6), 929-930.

Strack, F. (2017). From Data to Truth in Psychological Science. A Personal Perspective. *Frontiers in Psychology, 8* (702). doi: 10.3389/fpsyg.2017.00702.

Strack, F., Martin, L. L., & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality & Social Psychology, 54*(5), 768-777.

Troje, N. F. (2002). Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. *Journal of Vision, 2*(5), 371-387.

Troje, N. F. (2008). Retrieving information from human movement patterns. In: Shipley, T. F. & Zacks, J. M. (eds.), *Understanding Events: How Humans See, Represent, and Act on Events,* 308-334, Oxford University Press.

Tseng, L-Y., Tseng, P., Liang, W-K., Hung, D. L., Tzeng, O. J. L., Muggleton, N. G., & Juan, C-H. (2015). The role of superior temporal sulcus in the control of irrelevant emotional face processing: A transcranial direct current stimulation study. *Neuropsychologia, 64,* 124–133.

Wagenmakers, E.-J., Beek, T., Dijkhoff, L., Gronau, Q. F., Acosta, A., Adams, R. B., Jr., Albohn, D. N., Allard, E. S., Benning, S. D., Blouin-Hudon, E.-M., Bulnes, L. C., Caldwell, T. L., Calin-Jageman, R. J., Capaldi, C. A., Carfagno, N. S., Chasten, K. T., Cleeremans, A., Connell, L., DeCicco, J. M., Dijkstra, K., Fischer, A. H., Foroni, F., Hess, U., Holmes, K. J., Jones, J. L. H., Klein, O., Koch, C., Korb, S., Lewinski, P., Liao, J. D., Lund, S., Lupiáñez, J., Lynott, D., Nance, C. N., Oosterwijk, S., Özdoğru, A. A., Pacheco-Unguetti, A. P., Pearson, B., Powis, C., Riding, S., Roberts, T.-A., Rumiati, R. I., Senden, M., Shea-Shumsky, N. B., Sobocko, K., Soto, J. A., Steiner, T. G., Talarico, J. M., van Allen, Z. M., Vandekerckhove, M., Wainwright, B., Wayand, J. F., Zeelenberg, R., Zetzer, E. E., Zwaan, R. A. (2016). Registered Replication Report: Strack, Martin, & Stepper (1988). *Perspectives on Psychological Science*, *11*(6), 917-928.

Wilson, M., & Knoblich, G. (2005). The case for motor involvement in perceiving conspecifics. *Psychological Bulletin*, *131*(3), 460.

Wood, A., Lupyan, G., Sherrin, S., &Niedenthal, P. (2016a). Altering sensorimotor feedback disrupts visual discrimination of facial expressions. *Psychonomic Bulletin & Review, 23* (4), 1150-1156.

Wood, A., Rychlowska, M., Korb, S., & Niedenthal, P. (2016b). Fashioning the face: sensorimotor simulation contributes to facial expression recognition. *Trends in Cognitive Sciences, 20*(3), 227-240.

World Medical Association (2013).Ethical principles for medical research involving human subjects. *Journal of the American Medical Association, 310*(20), 2191-2194.

Yonemitsu, F., Sung, Y., Naka, K., Yamada, Y., & Marmolejo-Ramos, F. (2017). Does weight lifting improves visual acuity? A replication of Gonzalo-Fonrodona and Porras (2013). *BMC Research Notes, 10* (362). DOI: 10.1186/s13104-017-2699-1